winds, as deduced from hourly readings of the self-registering anemometers, have not been computed during the year 1896, but the relation between the resultants from two observations per day, and those from twenty-four hourly observations can be estimated by a comparison between Tables V and VI, pp. 544 and 545 of the SUMMARY for 1894.

The general agreement of the resultant winds within any climatological section depends upon the nature of the irregularities in the immediate neighborhood of the station; an intimate agreement can not be expected when stations are so far apart and so variously located as those of the Weather Bureau. In such cases as that of Erie, Cleveland, Sandusky, and Toledo, all similarly located on the south shore of Lake Erie, the agreement is very close, so, also, with Block Island and Nantucket.

FREQUENCY OF THUNDERSTORMS.

The successive MONTHLY WEATHER REVIEWS have given for each day and each State the number of thunderstorms reported by both regular and voluntary observers. Tables VI and VII give a summary of these monthly tables. In order to ascertain the relative frequency of thunderstorms, as explained in the SUMMARY for 1894, it is proper to divide the number of storms reported by the number of stations in order to deduce the average number per station. The results of this division are given in the eighth column of Table B, which shows

TABLE B.—*Frequency of thunderstorms and auroras during* 1896.

State.	Areas in units of 10,000 sq. miles.	Number of stations.		Reduction factor.	Total for 1896.		Frequency per station.	
		Needed.	Reporting.		Thunderstorms.	Auroras.	Thunderstorms.	Auroras.
Alabama	5.1	128	45	2.8	376	0	8.4	0.00
Arizona	11.4	385	30	12.8	213	0	7.1	0.00
Arkansas	5.2	130	40	3.2	465	0	11.6	0.00
California	15.8	395	115	3.4	381	0	3.3	0.00
Colorado	10.4	260	70	3.4	562	7	8.0	0.10
Connecticut	0.5	12	20	0.6	270	38	13.5	1.90
Delaware	0.2	5	6	0.8	111	16	18.5	2.67
District of Columbia	0.01	0.2	2	0.5	33	1	16.5	0.50
Florida	5.9	148	30	4.9	837	0	27.9	0.00
Georgia	5.8	145	45	3.2	343	1	7.6	0.02
Idaho	8.1	215	35	8.3	298	27	8.5	0.77
Illinois	5.5	138	80	1.8	1,441	57	18.0	0.71
Indiana	3.4	85	40	2.4	529	12	13.2	0.30
Indian Territory	6.9	172	5	34.4	36	0	7.2	0.00
Iowa	5.5	138	80	1.7	1,204	72	15.0	0.90
Kansas	8.1	202	65	3.1	792	35	12.2	0.54
Kentucky	3.8	95	40	2.7	375	7	9.4	0.18
Louisiana	4.1	102	45	2.3	781	0	15.1	0.00
Maine	3.5	88	15	5.9	134	97	9.6	6.47
Maryland	1.1	28	30	0.9	496	38	16.5	1.27
Massachusetts	0.8	20	65	0.3	539	95	8.3	1.46
Michigan	5.6	140	70	2.3	879	130	12.6	1.86
Minnesota	8.4	210	60	3.5	839	194	14.0	3.23
Mississippi	4.7	118	45	3.0	564	1	12.5	0.02
Missouri	6.5	162	85	1.0	1,945	17	22.9	0.20
Montana	14.4	360	35	1.4	175	128	5.0	3.66
Nebraska	7.6	190	90	2.4	808	67	9.0	0.74
Nevada	11.2	280	35	8.0	247	12	7.1	0.34
New Hampshire	0.9	22	20	1.1	187	121	9.4	6.05
New Jersey	0.8	20	45	0.4	701	52	15.6	1.16
New Mexico	12.1	302	30	12.1	277	0	9.2	0.00
New York	4.7	118	65	2.0	650	114	10.0	1.75
North Carolina	5.1	128	50	2.6	1,267	2	25.3	0.04
North Dakota	7.5	185	35	6.2	241	224	6.9	6.40
Ohio	4.0	100	125	0.8	2,016	123	16.3	0.06
Oklahoma			18		130	0	7.2	0.00
Oregon	9.5	238	45	5.3	119	1	2.7	0.02
Pennsylvania	4.6	115	70	1.6	868	38	17.3	0.55
Rhode Island	0.1	2	6	0.3	57	15	9.5	2.50
South Carolina	3.4	85	35	2.4	582	0	16.0	0.00
South Dakota	7.6	190	40	4.8	280	70	7.0	1.75
Tennessee	4.6	115	35	3.3	716	5	20.5	0.14
Texas	27.4	686	75	9.1	568	1	7.4	0.04
Utah	8.4	210	25	8.4	226	0	9.0	0.00
Vermont	1.0	25	12	2.1	138	46	11.5	3.84
Virginia	6.1	152	35	4.3	543	7	15.2	0.20
Washington	7.0	175	45	3.9	101	21	2.2	0.48
West Virginia	2.3	58	30	1.9	421	5	14.0	0.17
Wisconsin	5.3	132	55	2.2	895	191	16.3	3.47
Wyoming	9.8	245	10	24.5	45	6	4.5	0.60

that the greatest frequencies per station per year were: Florida, 27.9; North Carolina, 25.3; Missouri, 22.9; Tennessee, 20.5. The smallest frequencies were: California, 3.3; Montana, 5.0; Oregon, 2.7; Washington, 2.2.

The product of the observed number of thunderstorms by the reduction factors given in column five of Table B would give the approximate total number of thunderstorms for the respective States, which total number, of course, depends largely on the area of the State, and is omitted from this table, as it has no meteorological significance as compared with the frequency per station.

FREQUENCY OF AURORAS.

Tables VIII and IX give a summary of the detailed tables of auroral frequency in the respective MONTHLY WEATHER REVIEWS. In the absence of more precise knowledge, it is assumed that the number of observers reporting all auroras is the same as those reporting all thunderstorms; the total number of either class of observers is decidedly less than the total number of those who report rainfall and temperature, and is estimated to be as given in the fourth column of Table B. The total number of auroras reported divided by the number of observing stations for any State gives the relative frequency per station, and this number relates to a physical phenomenon, and is comparable with similar ratios for other parts of the world, provided the aurora is so low as not to be obscured by a cloudy sky. On the other hand, if the auroral light emanate from a region far above the cloud, then a further correction for cloudiness is needed, but this has not been applied in the present case, as the Editor believes that we have no certain proof as to the extreme altitude of the auroras, and that, on the other hand, there are many reasons to believe that the light emanates from the cloud region itself.

The States that report the greatest frequency of auroras per station are: Maine, 6.47; North Dakota, 6.40; New Hampshire, 6.05; Vermont, 3.84; Montana, 3.66; Wisconsin, 3.47; Minnesota, 3.23.

SUNSHINE AND CLEAR SKY.

The successive MONTHLY WEATHER REVIEWS have presented in Table XI the percentages of sunshine, as recorded by self-registers of either the photographic or the thermometric type, and the corresponding chapter in the text has called attention to the systematic differences between the instrumental and the personal observations of the average daily sunshine or clear sky. These differences are, doubtless, in part due to what may be called instrumental and personal peculiarities as affecting the respective records. In addition to these peculiarities we must consider the fact that the photographic register gives essentially a record of the duration of a certain limiting intensity of actinic effect of direct sunshine; the thermometric register gives a record of the duration of certain limiting values of the total heat of direct sunshine plus atmospheric and terrestrial radiation; the personal observation of cloudiness aims to give the percentage of area of clear sky. There is no simple relation between these three classes of data, and yet as the records are often used indiscriminately, each for the other, it becomes interesting to ascertain how nearly they agree. The differences between the instrumental and personal records, as given from month to month, are collected together in the two following tables for the photographic and the thermometric stations respectively. A cursory examination of these tables shows that there is an annual periodicity by reason of which the differences are, in both cases, larger in the summer than in the winter months. This annual period is apparently due to the greater altitude of the sun in the summer season by reason of which both the actinic and the thermal power of the sun's rays is increased, wherefore the instrumental records must be interpreted to mean that, for the same percentage of clear sky as determined by personal estimates, there is, in the summer time, a larger proportion of hours during which the limiting thermal or actinic effect prevails. The stations are arranged from south to north in the order of latitude, that is to say, in the order of

possible duration of sunshine. The differences between instrumental and personal records do not vary at all regularly with latitude in the case of the photographic stations, but do have an appreciable increase with latitude in the case of most of the thermometric stations; we may infer that the change of latitude coupled with the change of local peculiarities of the stations affects the thermometric intensity of solar rays more than it does the actinic intensity.

TABLE C.—*Instrumental records minus personal estimates at photographic stations.*

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual mean.
Galveston	+ 1	− 1	+ 4	+ 9	+ 7	+ 6	+15	+ 8	+ 8	+ 5	− 7	+ 3	4.8
Savannah	+12	+14	+11	+13	+14	+29	+15	+ 6	− 1	+ 5	+ 2	− 3	9.8
Phœnix	+ 5	+17	+22	+11	+ 9	+11	+23	+25	+10	+ 8	+12	+ 6	13.2
San Diego	+ 6	+ 7	+16	+ 6	+ 9	+ 2	− 4	−11	− 4	0	+ 5	+12	3.7
Los Angeles	.....	.....	.....	.....	.....	.....	.....	.....	.....	+ 9	.....	+ 7	.....
Santa Fe	+14	+11	+12	+16	+17	+15	+18	+19	+ 8	+18	+16	+11	14.6
Dodge City	+ 8	+ 7	+12	+ 8	+ 5	+16	+ 8	+ 8	+ 8	+ 8	+ 3	+ 4	7.8
Kansas City	− 3	+ 1	+ 6	+ 5	+12	+10	+ 9	+ 4	+ 5	+ 5	+ 5	− 3	4.6
Washington	0	− 7	0	− 4	+ 5	+ 7	+12	+ 5	+ 1	+ 3	+ 3	+ 8	2.8
Denver	+23	+17	+23	+20	+ 8	+17	+10	+ 7	+ 8	+11	+27	+19	15.8
Cheyenne	.....	.....	.....	.....	.....	.....	.....	.....	+16	+23	+21	+13	.....
Eureka	− 1	+ 7	+ 1	+ 4	+ 6	+ 1	− 2	− 9	+ 4	− 1	+ 2	− 7	0.4
Omaha	.....	.....	.....	.....	.....	.....	.....	+10	+ 9	+ 9	+ 4	.....	.....
Salt Lake City	+15	+20	+22	+28	+27	+34	+31	+23	+29	+12	+19	+24	23.7
Cleveland	− 3	0	+10	+14	+ 9	+13	+13	+11	*	.....	.....	.....	.....
Norfolk	.....	+ 1	+ 8	+ 9	+10	+14	+10	+15	+ 6	+10	+ 1	+ 3	.....
Eastport	+11	+ 4	+ 4	+10	+17	+15	+11	+13	+ 9	+ 7	+ 4	+11	10.5
Portland, Oreg.†	− 9	− 8	0	− 7	− 9	+ 1	+ 5	+10	− 2	− 1	+12	−11	− 1.6
Bismarck	− 5	− 4	+ 6	+ 4	+ 3	+ 7	+ 4	+10	+ 1	− 1	− 1	+ 2	2.2
Helena	− 3	0	+ 1	+ 2	+ 5	+ 3	+ 6	+ 7	+ 6	+ 8	+ 1	+ 4	3.3

*Photographic record ceases; thermometric record begins in November. †Records by both methods.

TABLE D.—*Instrumental records minus personal estimates at thermometric stations.*

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual mean.
Tampa	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	− 4	0	.....
New Orleans	+ 1	+ 1	+ 4	+ 2	+ 3	0	+ 1	+ 1	0	2	− 1	+ 3	+ 1.4
Vicksburg	+ 2	+ 4	+ 6	0	+ 5	+ 7	+ 4	+ 6	+ 2	+ 3	+ 2	+13	+ 1.5
Atlanta	+ 4	+ 6	+23	+20	+33	+18	−13	.....	− 3	− 3	− 1	− 2	+ 6.9
Wilmington	+ 1	+ 7	+11	+14	+16	+10	+16	+12	+11	+ 8	0	+ 5	+ 9.2
Chattanooga	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+ 1	− 5	.....
Little Rock	+ 5	+15	+15	+36	+18	+29	+29	+21	+12	+20	+11	+18	+19.0
Raleigh	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+ 8	+ 9	.....
Fresno	.....	.....	.....	.....	.....	.....	+ 8	+ 4	+ 6	+ 9	+ 9	+ 3	.....
Louisville	+ 7	+ 5	+14	+26	+22	+38	+24	+12	+10	+10	+12	+15	+16.3
San Francisco	+ 2	− 1	+ 5	+18	+ 1	+ 7	+ 9	+10	+ 5	+ 3	+ 9	+ 7	+14.6
Baltimore	+ 3	+ 5	+ 3	− 1	− 2	+ 8	+11	+ 4	+ 4	−10	− 8	+ 3	+ 1.8
Cincinnati	0	+ 8	+ 8	+23	+24	+24	+27	+19	+19	+19	+ 2	− 4	+13.2
St. Louis	+ 7	+11	+10	+19	+19	+22	+16	+12	+14	+ 8	+10	+15	+13.6
Columbus	+ 5	+ 9	+12	+17	+14	+10	+11	+10	+ 7	+12	+ 3	− 7	+ 8.6
Indianapolis	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+ 8	+ 7	.....
Philadelphia	+12	+13	+15	+24	+28	+30	+36	+27	+17	+ 8	+12	+17	+19.9
New York	+ 3	+10	+ 8	+ 8	+ 3	+ 1	− 1	− 2	+ 1	− 1	+12	+14	+14.7
Binghamton	.....	.....	.....	.....	.....	.....	.....	.....	.....	− 1	0	+ 3	.....
Boston	+ 4	+ 6	+11	+ 8	+12	+ 5	+ 5	+ 7	+ 9	+ 7	+ 6	+14	+ 7.8
Chicago	+ 5	+ 8	+11	+ 9	+12	+21	+ 8	+13	+11	+ 5	0	0	+ 9.4
Cleveland.*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	− 6	.....	.....
Des Moines	+11	+18	+15	+26	+28	+22	+ 3	+ 7	+ 3	+ 8	+ 3	+ 3	+12.2
Detroit	+ 7	+ 7	+ 7	+10	+16	+ 9	+ 5	+15	+10	+ 3	+ 8	+ 7	+ 8.7
Dubuque	.....	.....	.....	.....	.....	+26	+25	.....	.....	− 2	− 4	− 1	.....
Albany	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+12	.....
Buffalo	+ 8	+16	+17	+14	+10	.....	+28	+33	+14	+ 9	+ 2	− 1	.....
Rochester	+23	+20	+ 9	+13	+18	+ 7	+ 6	+ 5	+ 7	− 3	− 1	+ 2	+ 8.8
Portland, Me.	+17	+10	+12	+19	+13	+22	+23	+19	+15	+ 8	+11	+14	+15.2
Minneapolis†	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Portland, Oreg.‡	− 5	− 7	+ 1	− 7	− 9	0	+ 5	+11	− 2	+ 2	+12	− 8	− 0.6
Seattle	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	− 9	− 3	.....
Independence	.....	+13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

*Changed to "T" in November. †No personal record. ‡Records by both methods.

REDUCTION OF PRESSURES AND TEMPERATURES.

The following table (E) gives the data necessary for computing the mean annual temperatures and pressures reduced to sea level in accordance with the principles explained more fully by Mr. Park Morrill in the SUMMARY for 1895 (Vol. XXIII, page 492). The temperatures are first reduced to sea level by applying the general reduction of 2° F. per 1,000 feet of altitude, plus a station correction determined from a discussion of normal data. These results are charted and a system of smooth isotherms is drawn, such that the individual stations agree usually with the reduced temperatures within a fraction of a degree. The column temperatures used for computing the reduction of pressure to sea level are obtained by subtracting one-half of the above general reduction from the temperatures read off from the system of sea-level isotherms. With these reduction temperatures (in column 7) and the observed station pressures given in column 4 and the mean dew-point in column 6, the reduced barometer is computed by a method based on the formula recommended by the International Meteorological Committee. The pressures given in the 4th column of Table E differ from those in the 2d column of Table I, by reason of the application of the correction for the influence of local gravity, and are, therefore, barometric pressures as distinguished from barometric readings. Similarly the reduced pressures in the 8th column of Table E represent annual sea-level pressures, computed by making due allowance for the influence of the known force of gravity in giving weight to air whose density depends on the temperature and the moisture that is assumed to exist between the station and sea level.

We attain to a more natural system of isobars by reducing pressures upward, since in this case we have to deal with real instead of hypothetical air, whose temperature and moisture can be determined by actual observation instead of arbitrary assumptions, and whose movements are of the greatest importance in the study and prediction of the weather. In the last column of Table E are given the pressures reduced upward to 10,000 feet by the same process that was used for reducing to sea level, and by the help of the small table, F, which is quoted from the SUMMARY for 1895, page 494, but is changed so that the temperature argument is now the column temperature instead of the sea-level temperature.

TABLE E.—*Reduction data for* 1896.

Station.	Elevation.	Latitude.	Mean observed pressure.*	Mean observed temperature.	Mean dew-point.	Mean reduction temperature.	Mean pressure reduced to sea level.	Mean temperature reduced to sea level.	Mean pressure at 10,000 feet altitude.
1	2	3	4	5	6	7	8	9	10
New England.	*Feet.*	° ′	*Inch.*	° *F.*	° *F.*	° *F.*	*Inch.*	° *F.*	*Inch.*
Eastport	76	44 54	29.91	41.3	33	41.4	30.00	41.5	20.52
Portland, Me.	103	43 39	29.89	44.6	38	44.7	30.00	44.8	20.56
Northfield, Vt.	872	44 10	29.09	40.8	34	41.7	30.05	42.6	20.55
Boston, Mass.	125	42 21	29.89	49.2	39	49.3	30.03	49.4	20.67
Nantucket, Mass.	14	41 17	30.02	48.7	43	48.7	30.04	48.7	20.66
Block Island, R. I.	27	41 10	30.01	49.0	43	49.0	30.04	49.0	20.67
New Haven, Conn.	107	41 18	29.92	49.3	40	49.4	30.04	49.5	20.67
Middle Atlantic States.									
Albany, N. Y.	97	42 39	29.95	48.4	40	48.5	30.06	48.6	20.67
New York, N. Y.	314	40 43	29.71	51.2	43	51.5	30.05	51.8	20.71
Harrisburg, Pa.	377	40 16	29.67	52.3	44	52.7	30.07	53.1	20.75
Philadelphia, Pa	117	39 57	29.95	54.5	43	54.6	30.07	54.7	20.77
Baltimore, Md	123	39 18	29.94	55.8	43	55.9	30.06	56.0	20.79
Washington, D. C.	112	38 54	29.96	55.5	44	55.6	30.09	55.7	20.81
Lynchburg, Va.	685	37 25	29.35	57.6	47	58.3	30.08	59.0	20.85
Norfolk, Va.	57	36 51	30.02	60.0	51	60.1	30.08	60.2	20.87
South Atlantic States.									
Charlotte, N. C.	773	35 13	29.25	61.1	48	61.9	30.07	62.7	20.90
Hatteras, N. C.	11	35 15	30.07	62.0	56	62.0	30.09	62.0	20.91
Kittyhawk, N. C.	9	36 00	30.07	60.4	53	60.4	30.08	60.4	20.88
Raleigh, N. C.	375	35 45	29.68	60.7	48	61.1	30.09	61.5	20.90
Wilmington, N. C.	78	34 14	30.01	63.3	54	63.4	30.09	63.5	20.93
Charleston, S. C.	52	32 47	30.06	66.5	58	66.6	30.11	66.7	21.00
Augusta, Ga.	180	33 28	29.89	65.3	53	65.5	30.08	65.7	20.96
Savannah, Ga.	98	32 05	29.99	67.4	57	67.5	30.09	67.6	21.00
Jacksonville, Fla.	43	30 20	30.03	69.6	59	69.6	30.08	69.6	21.02
Florida Peninsula.									
Jupiter, Fla.	28	26 57	30.02	73.4	65	73.4	30.05	73.4	21.06
Key West, Fla	22	24 34	30.02	76.4	68	76.4	30.04	76.4	21.10
Tampa, Fla.	36	27 57	30.03	71.4	63	71.4	30.06	71.4	21.04
East Gulf States.									
Atlanta, Ga	1,131	33 45	28.90	62.2	50	63.3	30.09	64.4	20.95
Pensacola, Fla	56	30 25	30.00	67.9	59	68.0	30.06	68.1	20.98
Mobile, Ala.	57	30 41	30.00	67.2	58	67.3	30.06	67.4	20.97
Montgomery, Ala	221	32 23	29.84	66.2	55	66.4	30.07	66.6	20.97